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A Bibliometric Analysis of Current Knowledge Structure and Research Progress Related to Sustainable Furniture Design Systems

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Abstract: Sustainable furniture design has emerged as a prominent area of research, focusing on the interrelationships among people, furniture, and the environment. Despite being in its nascent stage, this field has garnered attention from scholars across disciplinary boundaries, seeking to explore new opportunities for industrial development and innovative perspectives. The objective of this paper is to clarify the extent of the current research literature, present the current significant themes, and elaborate further on the developed and potential future research directions in sustainable furniture design. In this research, a systematic analysis of bibliometric performance and scientific mapping of literature on sustainable furniture design was carried out by examining 1578 published papers from 2002 to 2023 selected from the Web of Science database, utilizing BibliometrixR package, VOSviewer, and CiteSpace tools for the analysis. The findings indicate a marked increase in research output in this area since 2012, with China being the primary contributor, although not achieving the highest citation rates. Furthermore, the study identifies 713 instances of international collaborations among researchers from 81 countries, with China and the United States being the most frequent partners. The research direction of highly cited literature, journals with the most published papers on sustainable furniture design, and authors with high total citation rates indicate a prominent connection between sustainable furniture design and fields such as product technical science, environmental science, ecology, and material research. The analysis of co-citation and keywords reveals the evolution of research themes, these key issues include furniture-human body scale match, furniture structure and performance, lifecycle, carbon emissions reduction, furniture industry chain, artificial intelligence, new development, school furniture safety and quality, and furniture strength and load capacity, with the focus shifting from the ontology of furniture and the human body to the external scope, emphasizing the connection with life, the environment, and the future. The latest research highlights industry chains, artificial intelligence, and innovative development, reflecting the trends of future research topics as "multi-dimensional integration", "health and intelligence", and "environment and system" will be the direction for the next stage.

Keywords: furniture design; sustainable development; co-citation network analysis; bibliometrics

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1. Introduction

The global furniture market is undergoing rapid development, with demand for furniture surging in the wake of the ongoing pandemic from 2020 to 2022. According to Statista, global furniture production has gradually recovered since 2016, coinciding with the global economic recovery, and had reached $490 billion by 2019, indicating the entry of the global furniture market into a phase of steady growth. China Competition Information predicts that the global furniture market will expand to $650.7 billion by 2027, an increase of $140.9 billion compared to 2020, indicating a growth rate of 27.64% [1]. While the pandemic has had an impact on the trading situation of the furniture industry, the industry is expected to further integrate, leading to an acceleration of brand concentration

and the gradual strengthening of the advantages of leading enterprises in scale. Over the long term, this trend will contribute to the overall improvement in the quality of the industry's development [2].

Sustainability is a widely accepted concept in today's society and is considered a guideline for human social development. The World Commission on Environment and Development report "Our Common Future" in 1987 advocated for adherence to sustainable development, emphasizing that meeting the needs of the present should not compromise the ability of future generations to meet their own needs [3]. In the context of product design, sustainability involves considering the entire life cycle of a product, from conceptualization, repair, expansion, maintenance, or improvement during use, with the aim of optimizing resource allocation, reducing pollution and energy consumption, and improving the overall quality of life by coordinating the relationships between people, products, the environment, society, and other aspects.

In the furniture industry, governments worldwide have demonstrated their commitment to promoting sustainable development by developing policies and regulations aimed at encouraging furniture manufacturers to follow sustainability standards in production. China has been at the forefront of this movement, having established many national standards for furniture, including "Environmental Labeling Product Technical Requirements for Furniture" and "Office Furniture Quality Grading". These standards incorporate requirements for environmental friendliness, health, quality, and other aspects of furniture products [4]. Similarly, the standardized principles proposed by the Forest Stewardship Council (FSC) global certification system and the Program for the Endorsement of Forest Certification (PEFC) system are crucial to the sustainability of furniture [5]. The Global Organic Textile Standard (GOTS) also certifies textile interior furnishings used in furniture and seeks to provide guidance principles for sustainable design and production for furniture manufacturer. Additionally, the EU has introduced multiple labels and certifications, such as the EU Ecolabel, along with policies such as the Sustainable Finance Action Plan, in order to promote environmentally friendly and sustainable furniture manufacturing [2]. The implementation of these standards and certifications can facilitate the furniture industry's development towards a more sustainable direction, fulfill consumers' demand for environmental protection, and foster sustainable operations.

Notwithstanding the growing importance of sustainable furniture design, there is still a need to increase awareness of the prospects of sustainable design publications in the furniture industry. Current overviews of sustainable furniture design are rare, and typically involve systematic reviews conducted by experts from their research perspectives. For example, Bumgardner and Nicholls [6] consider how green practices and communication with consumers in design can influence or even enhance the competitiveness of enterprises. Suandi et al. [7] explore multiple themes such as design guidelines, design criteria, design preferences, design optimization, design assessment and evaluation, design decision-making, strategic planning, design strategies, integrated eco-design, eco-design tools, and more, with the aim of identifying common sustainability characteristics in the furniture design process and establishing new standards for the furniture industry. While these expert reviews rely on unique insights to analyze one or several perspectives on sustainable furniture design, they lack a comprehensive assessment of the current field and fail to provide a cognitive blueprint for future sustainable furniture design [8]. Traditional systematic evaluations also have limitations, as researchers conducting reviews must possess a high level of expertise to eliminate any bias tendencies, and the growing interest in sustainable furniture design has led to a large volume of research literature that may limit the sample size of the literature included in the study, thereby excluding key publications and contributions. Sydor et al. [9] conducted a bibliometric analysis of technical literature on furniture design in the Scopus database, investigating the network of connections among countries, research centers, and scientists involved in furniture design, which has significant implications for the research methods and content of sustainable furniture design. Thus, there is an urgent need for tools that can handle large amounts of

scientific data to more systematically and comprehensively evaluate existing knowledge and research progress in the field of sustainable furniture design.

In the field of bibliometric research, several studies have been conducted to investigate the technical literature on furniture design. Sydor et al. [9] utilized bibliometric methods to examine the Scopus database and analyze the network of relationships among countries, research centers, and scientists involved in furniture design. Their comprehensive literature review also focused on the development methods and role of composite materials in interior design [10]. Meanwhile, Liu et al. [11] employed VOSviewer to quantitatively analyze the life cycle of sustainable furniture, and proposed an enhanced conceptual framework from the perspective of life cycle stages, which contributes to the advancement of sustainable furniture research. Moreover, in the field of sustainability research, there have been numerous studies that have applied similar methods to investigate various topics. Jia et al. [12] utilized Citespace to classify problems, mathematical models, and clustering solutions for urban transportation network design issues. Bonilla et al. [13] conducted a bibliometric analysis of academic articles indexed in Scopus and WoS databases using Bibliometrix R and Biblioshiny software packages to explore the evolution of human resources in this field. These studies have significant implications for the research methods and content of sustainability literature.

The objective of this study is to expand the conventional literature review of sustainable furniture design by utilizing bibliometric tools. The objective of the scientific literature is to shed light on four fundamental research questions regarding sustainable furniture design: Which publications and principal source journals are relevant? How is cooperation between different regions of the world? Who are the most influential institutions and authors? What are the research themes of the past, present, and future? The study aims to obtain a detailed understanding of the extent and interrelationships of the available research literature on sustainable furniture design, the existing key themes and their progression in sustainable furniture design research, the duration of each theme, and the research topics and future research requirements in sustainable furniture design. To the best of our knowledge, earlier literature reviews have not comprehensively addressed these questions. The contribution of this study is threefold. Firstly, given the absence of papers dealing specifically with bibliometric analysis of sustainable furniture design, the findings of this study are expected to fill this knowledge gap. These outcomes may be relevant to researchers from various fields, particularly new entrants in this area. Secondly, we investigate the development trends of sustainable furniture design, offering valuable insights for future research. Finally, the study underlines its established practical significance, thereby promoting its standardization and legalization.

2. Scientific Background

2.1. Sustainable Furniture Design

Sustainable furniture design involves minimizing the environmental impact of furniture design, optimizing resource efficiency, and ensuring the functionality and aesthetic appeal of furniture across all stages of its lifecycle, including design, production, disposal, use, decommissioning, and recycling. The origin of sustainable furniture design can be traced back to the 1970s, a period marked by an increasing environmental awareness, when designers began to consider the integration of sustainability into furniture design. In the 1980s, some designers began to focus specifically on the environmental impact of furniture design and proposed novel concepts and technologies. The 21st century saw a wider adoption of sustainable development principles, and furniture design gradually moved towards sustainability. Some designers incorporated eco-friendly materials and techniques, such as recycled, non-toxic, and renewable materials, into furniture design [14]. Additionally, designers have become increasingly interested in lifecycle management, designing furniture that is easy to disassemble and reuse while also extending its lifespan [15]. In recent years, intelligent manufacturing and digital technology have significantly impacted sustainable furniture design. Furniture companies are using intelligent manufacturing technology to

achieve customized production, reduce waste, and lower costs. Moreover, digital technology has expanded the possibilities for furniture design, manufacturing, and sales, thereby promoting the sustainable development of furniture [16]. Sustainable furniture design has gone through a long process, evolving from a concept to practical applications. Today, the widespread adoption of environmental principles and technological advancements has made sustainable design a trend and a necessity in the furniture industry.

2.2. Bibliometric Tools

Bibliometric analysis is a valuable method for producing a "scientific knowledge map," which can be considered a hybrid of "maps" and "spectra" that provides a visual representation of the knowledge landscape within a research field [17]. The scientific mapping process is complex and typically involves multiple stages, which are supported by software. In this study, we employed three commonly used tools, namely the BibliometrixR package (stable version), VOSviewer (version 1.6.19), and CiteSpace (version 6.2.R2), to perform bibliometric analysis and generate a scientific knowledge map. These tools are capable of compiling bibliographic data from the Web of Science (WOS) and play a crucial role in the academic communication system. By utilizing these tools, we aim to provide valuable insights into the research landscape of sustainable furniture design, which can be useful to researchers, practitioners, and policymakers.

Moreover, the three aforementioned software packages are complementary in nature, serving distinct functions in bibliometric research. The Bibliometrix R-package is an open-source toolkit that operates within the R environment, furnishing researchers with an array of tools to work with bibliometric data. It enables users to explore and visualize sample literature, providing a basic understanding of essential information and characteristics [18]. On the other hand, VOSviewer and CiteSpace are two Java-based applications, both free of charge. VOSviewer has a user-friendly graphical interface, facilitating the easy comprehension of large-scale bibliometric maps. In contrast, CiteSpace focuses on identifying critical junctures and pivotal moments in the development of specific fields, with an emphasis on the timeline view that accentuates the temporal dimension of the research corpus [19].

3. Method

This study utilized the Web of Science (WOS) core collection database to collect data on sustainable furniture design. The data collection process consisted of two stages: firstly, a subject search was conducted using keywords such as "sustainable furniture design", "furniture design", "low-carbon furniture design", and "green furniture design" without any time span to ensure a comprehensive retrieval of publications. Secondly, to ensure the relevance of the publications to sustainable furniture design, two authors manually assessed the titles, abstracts, and full texts of the publications, resulting in 1578 relevant articles. Subsequently, data analysis was performed using three commonly used bibliometric tools: the Bibliometrix R package (stable version), VOSviewer (version 1.6.19), and CiteSpace (version 6.2.R2), which allow for visual analysis in various ways and form user-friendly interfaces that complement each other in functionality and have results that are easy to understand. We conducted an analysis of annual publications, journals, authors and institutions, references, keywords, and other content using these three bibliometric software systems, and the results were discussed based on the analysis framework shown in Figure 1.

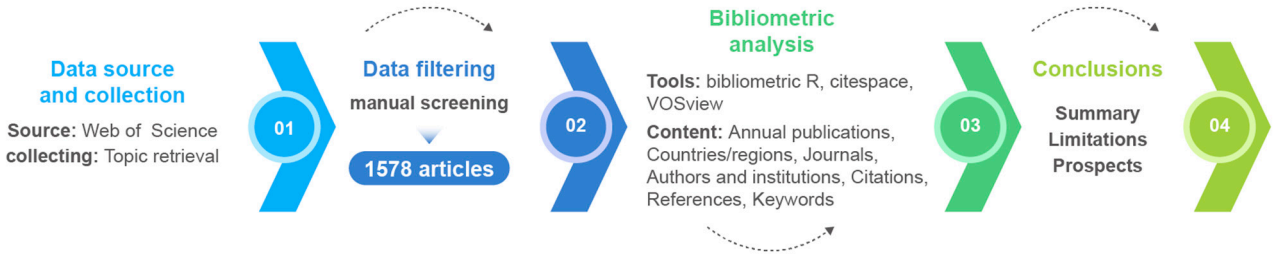


Figure 1. Research framework.

4. Results

In this study, Bibliometrix R was utilized to obtain data from the Web of Science (WOS) core collection database to extract 1578 relevant articles that strongly address sustainable furniture design from 2002 to 2023. As shown in Table 1, the results reveal that these articles were published across 834 sources, with an average citation of 13.02. Among them, 813 were original research articles and 77 were reviews. Furthermore, 2411 main keywords and 43,610 authors were involved in the research topic related to sustainable furniture design.

Table 1. Main information about data.

Description	Results
Timespan	2002:2023
Number of sources	834
Average citations per paper	13.02
Number of Documents	1578
Number of authors	4261
Number of original articles	813
Number of reviews	77
References	43,610
Keywords Plus (ID)	2411

4.1. Information about Annual Publications

From an annual publications perspective (Figure 2a), the study found that the number of publications concerning sustainable furniture design has been steadily increasing over the past 20 years, with a significant spike to over 179 publications in 2022. These findings indicate that sustainable furniture design research has been continuously gaining attention and interest, especially since 2012. In terms of citation analysis, as shown in Figure 2b, the distribution of citations is uneven, with higher values observed in 2007, 2012, 2016, and 2019, suggesting a greater emphasis on publications during these years. However, citation counts have decreased since 2019, which may be due to the need for more time for recent publications to accumulate citations and gain exposure and influence. Considering the increasing trend in the total number of publications, we analyze that the reason for this is that citations of more recent publications require time to accumulate, and these papers need more time to gain sufficient exposure, attention, and influence.

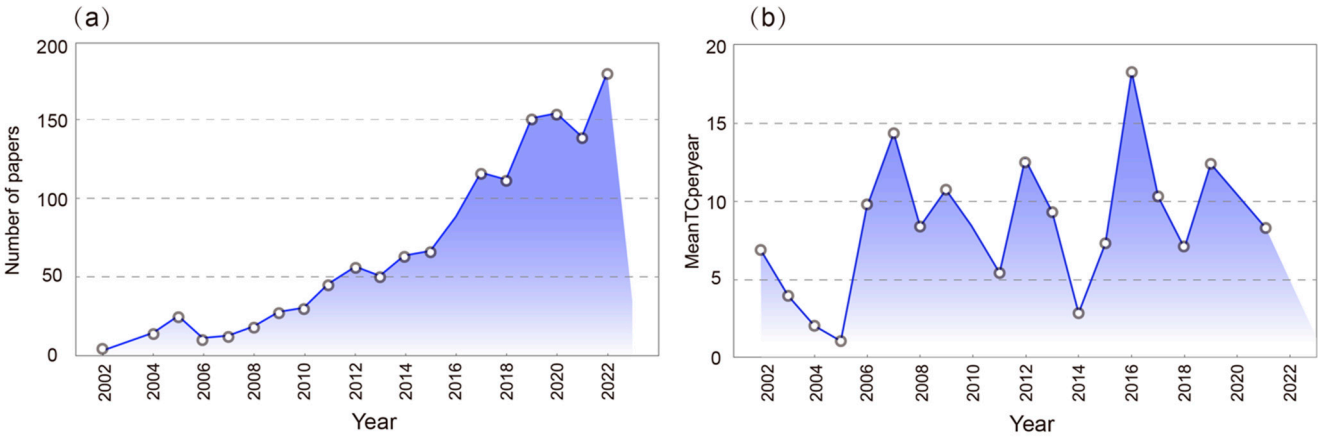


Figure 2. Contribution of sustainable furniture design research from 2002 to 2023, including (**a**) total publications, (**b**) mean total citations per year (MeanTCperYear).

4.2. Characteristics of Sustainable Furniture Design Publications by Countries/Regions

In this study, we present an analysis of the publication and collaboration information of 81 countries on the topic of sustainable furniture design, based on the corresponding author's country. Figure 3 indicates that China, the Americas such as the United States, Canada, and Oceania such as Australia and Indonesia have been the most active regions in sustainable furniture design research. We further evaluated the publication performance and citation frequency of different countries in this field. Figure 4a shows that China is the leading country in terms of publication output, followed by the United States (85), Brazil (62), and Italy (49). However, in terms of citation frequency, the most cited countries are the United States (5065 times), China (2094 times), Italy (1242 times), and the United Kingdom (1117 times). These results suggest that China's outstanding performance in publication output in sustainable furniture design may not necessarily reflect its research quality, as its citation rate is not among the highest. The number of papers published by a country and its citation frequency provide insights into the scientific research level of that country in a specific research field.

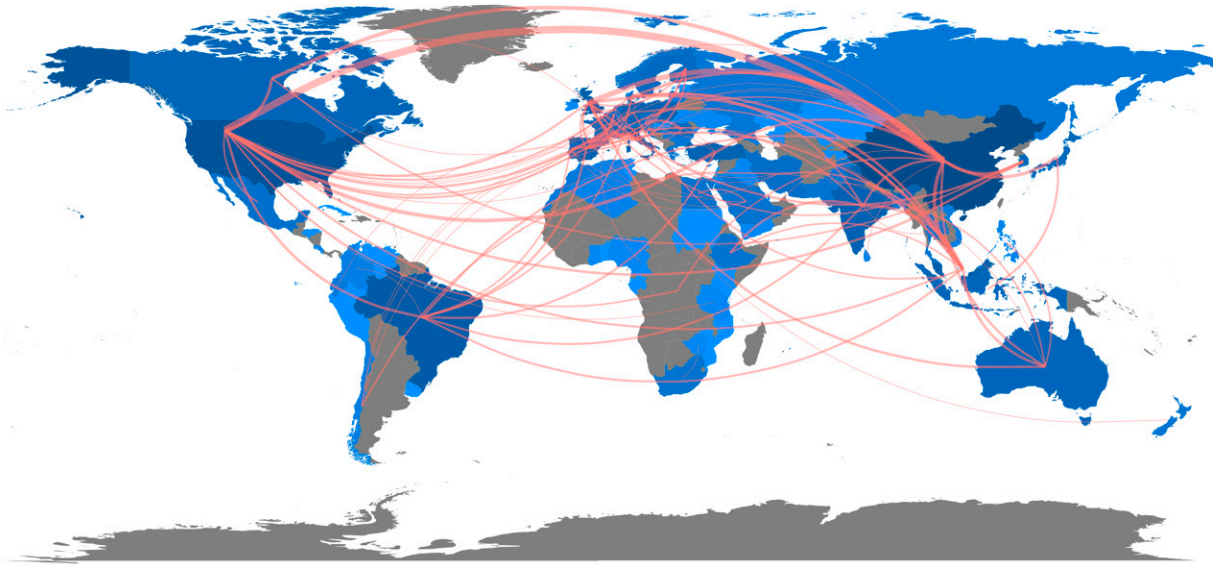


Figure 3. Global distribution of sustainable furniture design research and Collaboration Map.

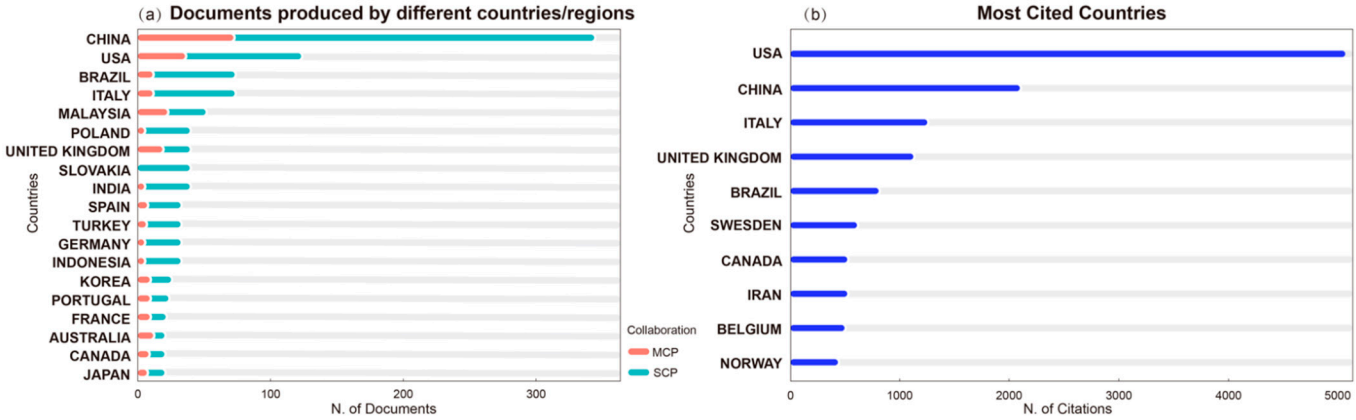


Figure 4. Publications (**a**) and citations (**b**) by country/region, MCP represents the number of papers co-authored with authors from other countries; SCP represents the number of papers co-authored with authors from the same country.

Visual analysis of literature databases offers valuable insights into international collaboration and research trends within the field of sustainable furniture design among influential countries/regions. Based on the statistical data on cooperation networks among countries/regions, 713 collaborations have been established within this field, among 81 countries. Notably, China has the broadest international cooperation in this area. Table 2 displays the cooperation situation between China and other countries, with the most frequent cooperation taking place between China and the United States (46 times), followed by the United Kingdom (23 times), Malaysia (11 times), Canada (11 times), Japan (8 times), and South Korea (8 times). It is noteworthy that Brazil and Italy rank third and fourth, respectively, in terms of the number of published papers, but have relatively closed structures and rarely collaborate with other high-productivity countries. By contrast, China and the United States have established mutually cooperative relationships and cemented their positions as vital contributors to the field.

Table 2. Collaboration frequency between China and other countries.

Country	Collaboration Frequency
USA	46
United Kingdom	23
Canada	11
Malaysia	11
Japan	8
Korea	8
Denmark	7
Turkey	7

4.3. Main Source Journals and Highly Cited Journals

Through an analysis of 1578 publications on sustainable furniture design, published in 834 peer-reviewed journals, this research reveals that this field spans various scientific disciplines including health science, environmental science, ecology, and materials research. Figure 5a highlights the top five journals that have published the most papers on sustainable furniture design, including bioresources (55 papers), forest products journal (49 papers), sustainability (41 papers), drvna industrija (33 papers), and ergonomics (20 papers). Furthermore, the top five journals with the highest total citation counts are applied ergonomics (928 citations), ergonomics (863 citations), journal of cleaner production (827 citations), forest products journal (772 citations), and building and environment (569 citations), as shown in Figure 5b. Additionally, Figure 5c reveals that applied ergonomics (13), journal of cleaner production (13), and ergonomics (12) are the top three

journals with the highest H-index. Lastly, Figure 5d shows the top 10 local citation sources in the reference list, with applied ergonomics (928 citations), ergonomics (863 citations), journal of cleaner production (827 citations), forest products journal (772 citations), and environmental science and technology (577 citations) being the top five journals in terms of citation frequency.

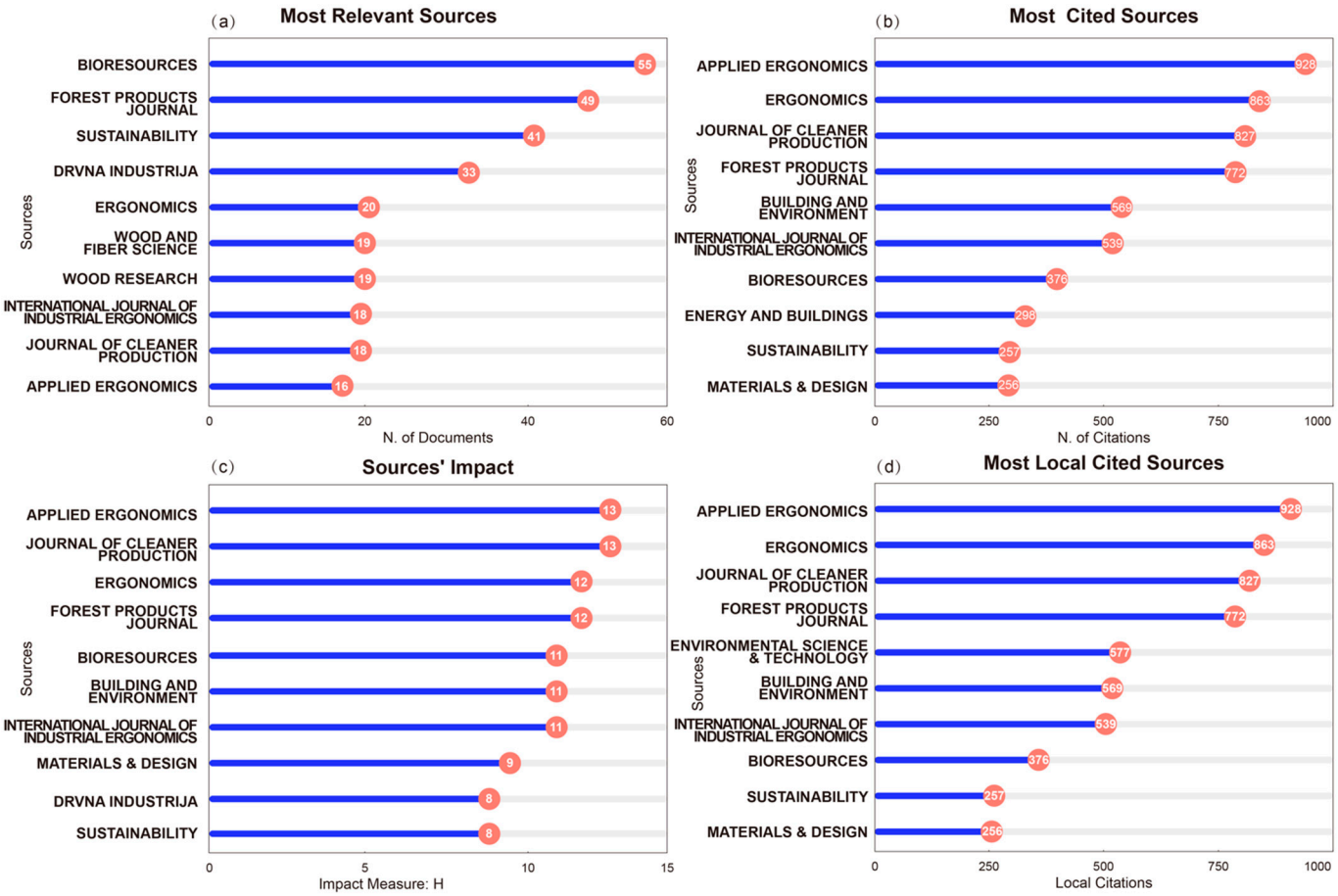


Figure 5. Most relevant sources from 2002 to 2023 (**a**), most cited sources (**b**), H-Index (**c**), most local cited sources (**d**). H-index is defined as an author that has at least H papers cited more than H times.

4.4. Highly Influential Authors and Cooperation of Institutions

A global citation analysis was conducted to identify highly cited authors in the field of sustainable furniture design. A selection of representative authors was made for discussion based on their research direction. Ten authors were identified and are listed in Table 3. Smardzewski's research focuses on the structural performance of furniture, including the impact of creep on joint stiffness used in cushion furniture structures [20] and the relationship between furniture's overall design stiffness and the stiffness coefficient of structural joints [21]. Castellucci [22] specializes in ergonomic principles for classroom furniture design based on the characteristics of students' body size. Ratnasingam's research investigates the level of automation in Malaysia's labor-intensive furniture manufacturing industry and its readiness for Industry 4.0 [23]. Tankut [24] conducts research on the development of optimization algorithms for furniture structural design, finite element methods, and their extensive application in the furniture industry. Zhang's research involves the identification of cognitive theory patterns to analyze the morphological features of the furniture and the recognition process of these features [25]. Kasal [26] investigates the bending moment capacity of mortise and tenon furniture joints under compression and tensile loads, and examines the influence of wood species, bonding types, and mortise and tenon dimensions

on the static bending moment capacity of joints under the same load conditions. Erdil's research focuses on the strength design for furniture and provides recommendations for improving furniture structures to achieve safe and reliable furniture [27]. Bumgardner [6] conducted research on ecosystem services related to furniture to improve the use and lifespan of furniture products. Hakansson [28] studied the application of wood-derived materials in 3D printing materials and their use in furniture with conductive components. Xu [29] researched the influence of health and environmental awareness on consumer purchases of green furniture.

Table 3. The ten influential authors contributing to sustainable furniture design research.

Rank	Author	TC	LTC	H-Index
1	Smardzewski	309	109	11
2	Castellucci	294	146	10
4	Tankut	145	58	7
10	Xu	140	23	2
3	Ratnasingam	109	98	7
9	Hakansson	103	23	6
5	Zhang	100	74	7
7	Erdil	97	57	6
8	Bumgardner	88	64	5
6	Kasal	62	47	6

Note: TC is global total citations; LTC is local total citations; H-index is defined as that an author has at least H papers cited more than H times (accessed on 29 March 2023).

We utilized the VOSviewer clustering technique to examine the cooperation network among 129 productive institutions in the field of sustainable furniture design. As shown in Figure 6, the resultant visualization graph showcases each institution as a node, with node size indicating the number of research papers published by the respective institution. The interlinkages between nodes represent collaborative efforts between institutions, with varying node colors signifying distinct clustering outcomes. Our clustering analysis generated 15 distinct clusters, comprising 215 items, with an aggregated link strength of 342. The top four clusters were examined in detail, and the findings indicated that the cluster spearheaded by Nanjing Forestry University, comprising ten institutions, concentrated on furniture performance [30,31], the impact of volatile organic compounds on furniture [32], new material applications [33], and smart furniture manufacturing [34,35]. On the other hand, the cluster led by Sichuan Agricultural University, including five institutions, prioritized the development of sustainable and eco-friendly materials for furniture [36], furniture recycling systems [37], home design for natural disasters [38,39], and the interplay of environment and sensory perception [40]. The cluster led by Technical University in Zvolen, which included four institutions, focused on the impact of the human environment on furniture [41], the influence of business models and marketing design [42,43], furniture sales, and trade [44,45]. The cluster led by Universiti Putra Malaysia, which included eleven institutions, mainly focused on research areas such as the development and application of bio-composite materials in furniture design [14,46], and the study of furniture culture [47,48].

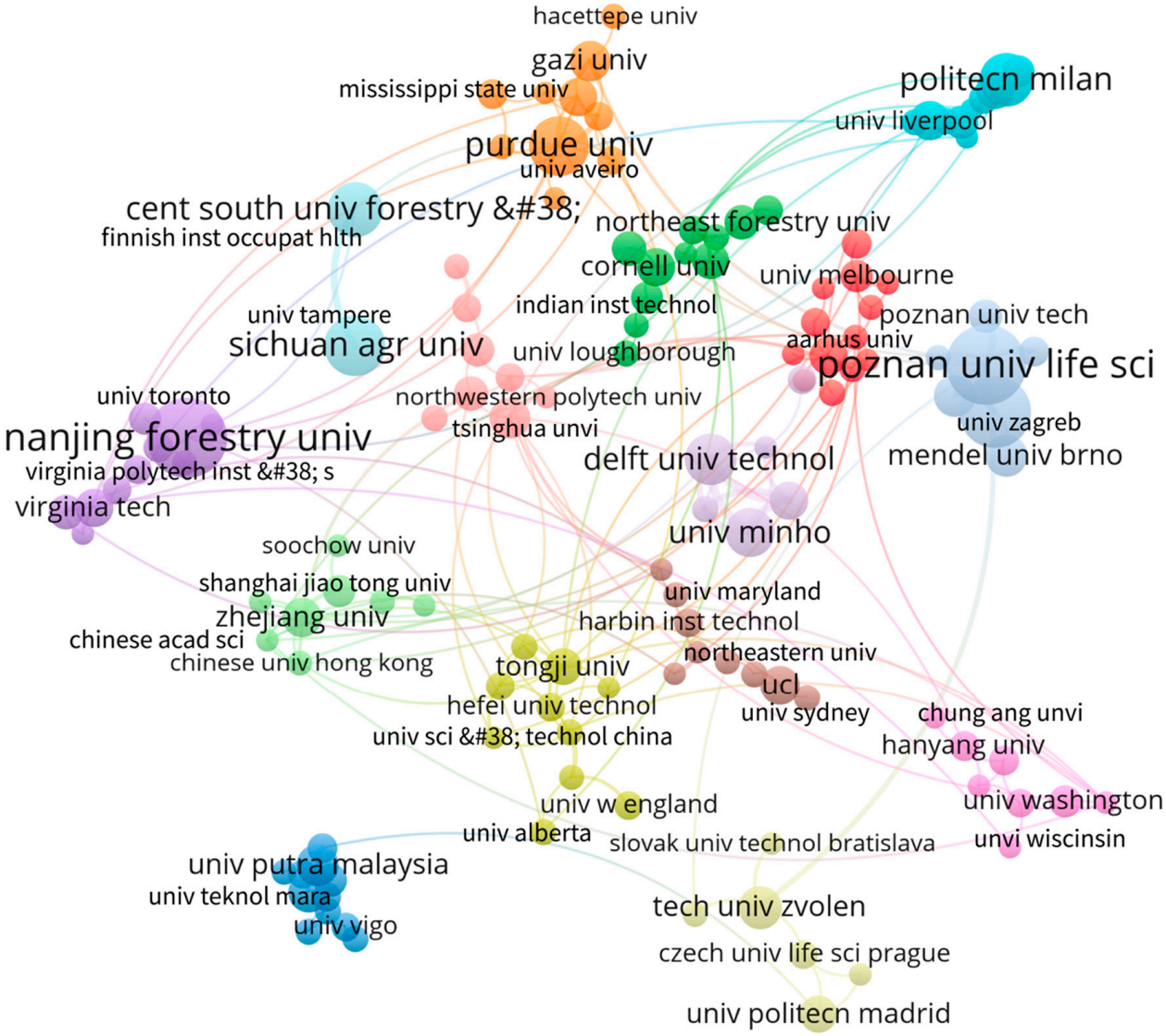


Figure 6. Collaboration network analysis of top 15 productive institutions.

4.5. Most Cited Papers

In the domain of sustainable furniture design, high citation counts serve as an important measure of paper impact. To evaluate the top globally cited papers from 2002 to the present, we compiled a list of the top 10 cited papers in Table 4. Among them, "Detection of Organophosphate Flame Retardants in Furniture Foam and U.S. House Dust" by Stapleton [49], published in Environmental Science and Technology, garnered the most citations with 577, and aimed to assess potential health risks associated with dust exposure. Other noteworthy papers include Gemser's research on the abilities and vocational training of furniture designers [50], Merrell's study on an interactive furniture layout system and interior design guidelines [51], Dangelico [52] published a paper in the Journal of Product Innovation Management, studying the role of external integration in the textile and upholstered furniture industries in developing sustainable new products, Gouvali's exploration of whether school furniture dimensions match children's anthropometry [53], Navas-Aleman's analysis of furniture design, marketing, and branding via a value chain approach [54], and Amick's examination of the effects of ergonomically designed office furniture interventions on reducing musculoskeletal symptoms [55]. Overall, these papers demonstrate that sustainable furniture research often involves a mix of natural and social sciences.

Our systematic review revealed that the top 10 most cited articles on sustainable furniture design were published prior to 2017 and encompassed a diverse range of topics, including furniture functionality and development [56], material and structural performance [57,58], marketing and supply chain systems [59,60], and school furniture [53,61]. It is important to acknowledge, however, that these findings do not necessarily encompass all noteworthy publications in the field, as newly released papers may require more time to gain recognition and subsequently accumulate citations.

Table 4. Top 10 cited published papers on sustainable furniture design based on global total citations (TC) from 2002 to 2023 (accessed on 29 March 2023).

Title	Author	Year	TC	LTC
Detection of organophosphate flame retardants in furniture foam and US house dust	Stapleton et al. [49]	2009	608	9
How integrating industrial design in the product development process impacts company performance	Gemser et al. [50]	2001	233	8
Interactive furniture layout using interior design guidelines	Merrell et al. [51]	2011	179	34
Developing sustainable new products in the textile and upholstered furniture industries: Role of external integrative capabilities	Dangelico et al. [52]	2013	142	3
Match between school furniture dimensions and children's anthropometry	Gouvali et al. [53]	2006	136	74
The impact of operating in multiple value chains for upgrading: the case of the Brazilian furniture and footwear industries	Navas-Alemán [54]	2011	121	0
Effect of office ergonomics intervention on reducing musculoskeletal symptoms	Amick et al. [55]	2003	114	3
Real-time monitoring weld quality of resistance spot welding for the fabrication of sheet metal assemblies	Jou [58]	2003	102	0
Promoting environmentally sound furniture by green public procurement	Parikka-Alhola [57]	2008	98	17
Influence of perceived value on purchasing decisions of green products in Brazil	Medeiros et al. [60]	2016	96	2

Note: TC is global total citations, and LTC is local total citations.

4.6. Analysis of Co-Reference Papers

In this study, we utilized co-citation analysis to identify the stratification and development trends of research areas in sustainable furniture design. We applied a parameter configuration that included time slices from 2005 to 2022 with a yearly span, using title, abstract, and author keywords as term data sources, noun phrases as term types, citation as node type, and a selection threshold of the top 25. The slice network was pruned using Pathfinder. The results were presented in Figure 7, a timeline visualization of the co-citation network, with horizontally displayed clusters numbered with a "#" symbol at the end of each cluster's timeline. The co-cited literature was grouped into six clusters, and each node in the network represents a cited article with edges depicting the co-citation relationship between the articles. Node size is proportional to the frequency of co-citation. The Modularity Q = 0.8742 indicates a significant knowledge structure, while the mean Harmonic Mean (Q, S) = 0.9027 indicates a high reliability of the clustering results.

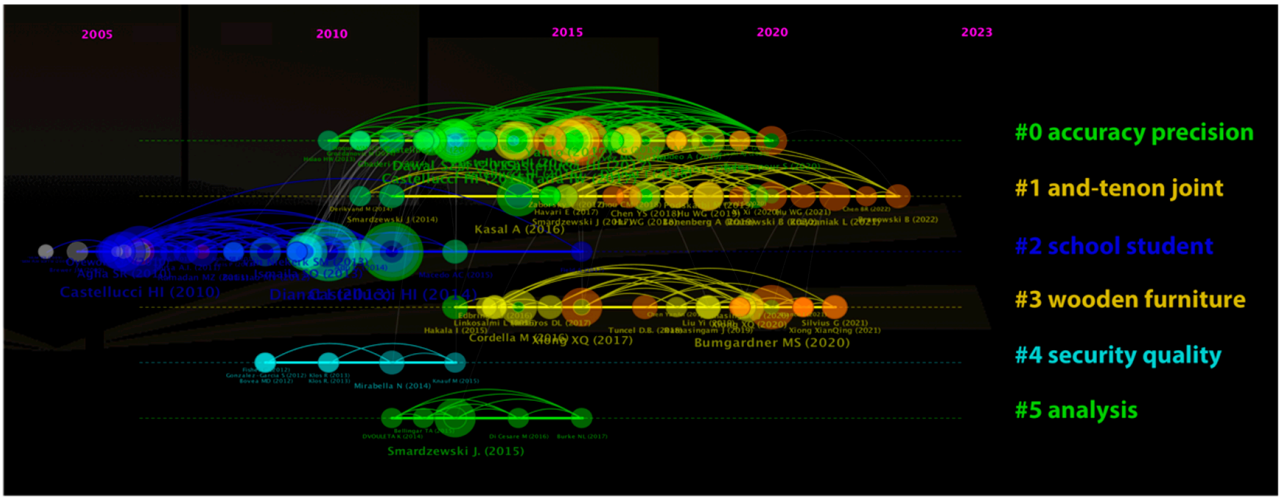


Figure 7. Timeline visualization of the co-citation clusters. The legend above the display area is marked every 5 years. Clusters are displayed horizontally along timelines and the label of each cluster is shown at the end of the cluster's timeline.

In our study, we present the detailed descriptions of six clusters, from Cluster #0 to Cluster #5, which are presented in Table 5. The consistency of the clustering from the network is evaluated by calculating the silhouette values of all six clusters, which range from 0.878 to 0.987, indicating sufficient consistency. The labeling of the clusters is based on the log-likelihood ratio (LLR), with closely related publications grouped together under the same cluster corresponding to a specific research topic. By analyzing the research span, appearance time, and duration of each cluster in Figure 8, we have identified both long-term and short-term research topics in sustainable furniture design.

Table 5. Co-citation clusters information.

Cluster	Silhouette	Mean (Year)	Description
Accuracy precision	0.996	2015	Accuracy of furniture matching human body scale
And-tenon joint	0.987	2013	Performance and function of furniture tenon and mortise connection structure
school student	0.878	2018	Matching relationship between students and school furniture
Wooden furniture	0.958	2011	Lifecycle and Carbon Emission Analysis of Wooden Furniture
Security quality	0.987	2018	Safety, quality, and ecological design of furniture
analysis	0.892	2016	Research on the overall strength and load capacity of furniture

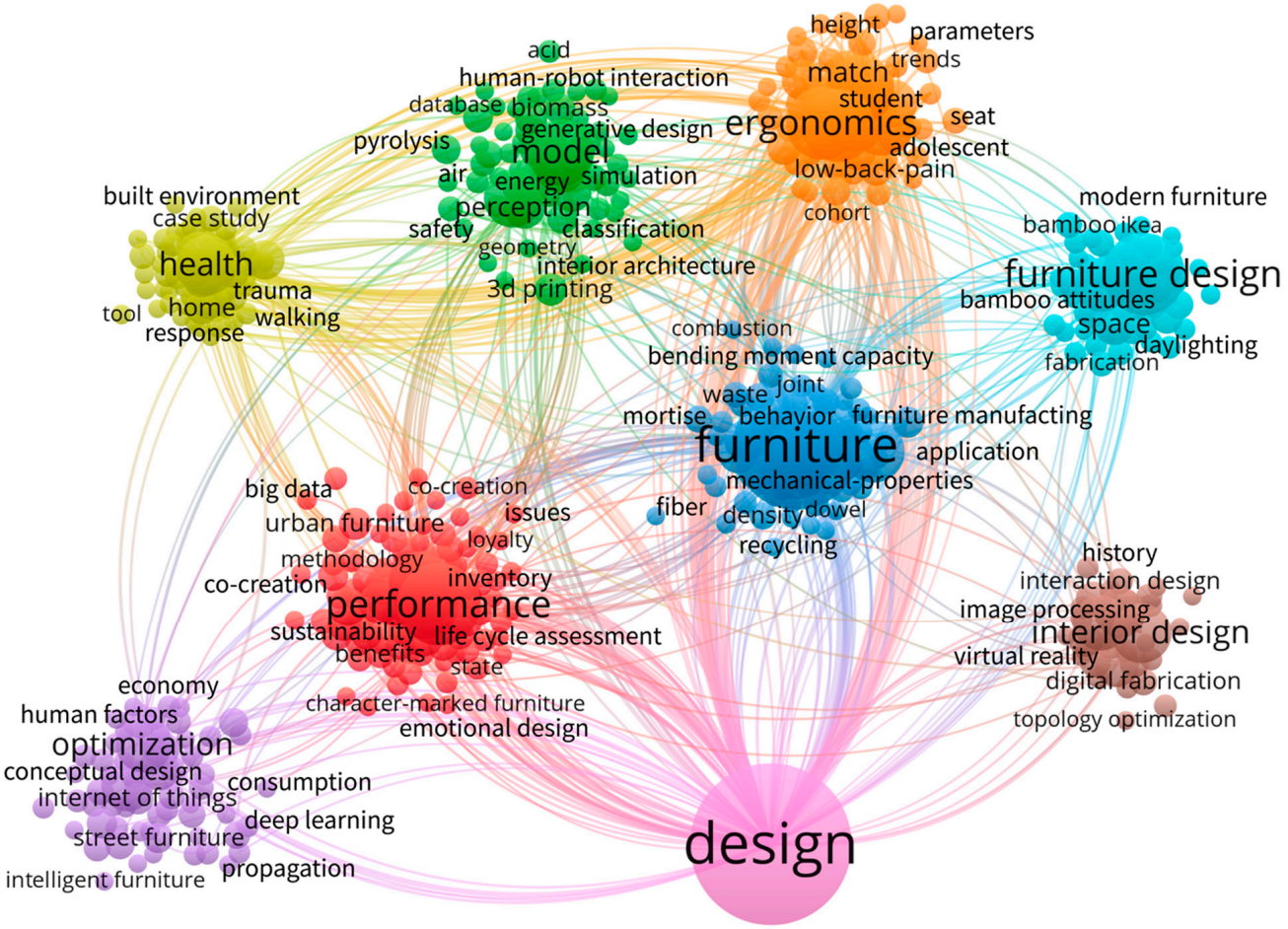


Figure 8. Keywords clustering.

4.6.1. Long-Active Research Topics

In the field of sustainable furniture design, there exist research topics that have persisted over the long term, having first appeared before 2013 and continuing to receive ongoing attention. These topics have been studied for at least 10 years and demonstrate a steady advancement and development. Among the six identified clusters, three can be categorized as long-term active research topics, namely Cluster #0 focusing on Accuracy precision, Cluster #1 on And-tenon joint, and Cluster #3 on Wooden furniture. The persistence of these topics signifies their significance in the field and their potential for further development and exploration.

(1) Cluster #0: Accuracy precision, corresponds to a research area in sustainable furniture design that focuses on achieving an accurate fit between furniture and the human body scale. This research topic is rooted in ergonomics and seeks to optimize or design furniture by taking into consideration human characteristics and needs. For instance, Dianat [62] emphasizes the significance of anthropometry in furniture ergonomics research and proposes methods such as sampling considerations, prototype evaluation, and testing to ensure user-centered design methods and processes. Sanjog [63] identifies ergonomic risk factors related to work and provides guidance for existing and upcoming factories in the furniture manufacturing industry. Furthermore, Dawal [64] studies the crucial human body measurement dimensions involved in household furniture used by the elderly in Malaysia, providing guidelines for designing user-friendly facilities for elderly people.

(2) Cluster #1: and tenon joint. This cluster represents the research topic of the mortise and tenon joint structure in wooden furniture, focusing on the method, performance, and function of the joint. The performance of mortise and tenon joints in modern wooden furni-

ture has been found to have significant implications for assembly looseness, load-bearing capacity, and other factors [65]. Kasal [66] conducted numerical analyses of the bending resistance and stiffness of round-end tenons of various sizes, finding that such analyses could provide a reasonable estimate of joint mechanical behavior and that incorporating these results into the engineering design process could enhance chair strength. Wu [31] undertook innovative research to optimize traditional Chinese mortise and tenon joints to meet the requirements of furniture product carbon reduction and environmental protection. Imirzi [67], on the other hand, investigated the elastic strength, stiffness, and modulus of locating pins and mortise and tenon joints in furniture under diagonal tensile and compressive loads through experiments, leading to the development of a method for measuring furniture frame structural performance.

(3) Cluster #3: Wooden Furniture. The literature in this group focuses on sustainable research of the lifecycle and carbon reduction of wooden furniture. By designing the furniture lifecycle, it is possible to reduce the impact on the environment and energy consumption at any stage of the lifecycle, and have more environmentally friendly features. Carbon footprint studies of wooden furniture can quantify the emission reduction effect brought by ecological design and provide corresponding production and management strategies [68]. Medeiros [69] used life cycle assessment (LCA) to consider the entire supply chain of office cabinets from cradle to grave, including pre-manufacturing, manufacturing, use, and end-of-life steps. The study showed that reusing, recycling, or recovering energy from waste would generate significant environmental benefits in major categories. If the greenhouse gas emissions of wooden furniture during its lifecycle do not exceed the amount of greenhouse gases that the material can store, then wooden furniture is a potential carbon sink. In addition, diversified innovation and reuse of discarded wooden furniture can reveal the hidden value of waste materials. This is of great significance to the country and enterprises in the concept of a circular economy [70].

4.6.2. Short-Term Research Topics

Short-term research topics first appeared before 2010, and there has been no large-scale sustained research in recent years. The three main themes of short-term research are: Cluster #2, High school student; Cluster #4, Security quality; Cluster #5, Analysis.

(1) Cluster #2: School student. In the research cluster of school furniture, the matching relationship between the anthropometric dimensions of different stages of student population and furniture is the focus of the study. These literature studies include static anthropometric dimensions of different races and discuss evaluation methods for different types of furniture. The height of chairs, the width of chairs, and the height of desks all need to match the corresponding dimensions [62]. The mismatch between classroom furniture and static anthropometric measurement values in multiple dimensions will directly affect students' sitting posture and health [71]. Evaluating the matching relationship between fixed furniture dimensions and students' anthropometric measurements, as well as the relationship with posture overload, are the key issues being focused on [72].

(2) Cluster #4: Security quality. The safety, quality, and ecological design of furniture is the fundamental elements of modern furniture design, which are strongly related to Cluster #3 Wooden furniture and can be seen as its preliminary research. Zanuncio [73] studied the population and usage environment, using ergonomics measurements of body data for different age groups to guide design, ensuring that furniture is more comfortable and safe for end-users. Oblak [74] analyzed the ecological quality of kitchen furniture and formulated the best business strategy to reduce environmental pollution from the perspective of production classification. Laurence [75] conducted a statistical quality control application study on wooden furniture such as tables and chairs in furniture manufacturing companies, including statistical quality control techniques for heartwood, damage, cracks, and discoloration, to ensure that products meet the prescribed standards.

(3) Cluster #5: Analysis. This cluster includes research on the overall furniture, its structure, and the design process. Berginc [76] analyzed the collaboration between the furniture industry and designers in the product development process. Better design and fresh ideas demonstrate strength and creativity and lead to more collaboration opportunities. Smardzewski [77] conducted research on spring-assisted structures and developed a numerical model for auxiliary compression springs suitable for office and home furniture seat structures. By changing the elastic modulus of the frame material and the geometric shape of the internal structure, the optimal structure to provide functions for rest and work furniture seats was determined. Cristiane [78] conducted a macro ergonomic analysis of furniture to improve design solutions for furniture improvements.

4.7. Keywords' Evolution and Co-Occurrence

An overview of the concentration and emerging trends in sustainable furniture design research can be obtained through keyword analysis. This study examined a total of 3998 author keywords and 2411 keyword plus, which are two types of keywords provided by Web of Science (WOS) for researchers. The author keywords are proposed by the authors to best represent the content of their papers, while the keyword plus is automatically generated by the WOS database and may not appear in the paper's title or author's keywords. Both types of keywords play an important role in academic publications. The extraction and analysis of keywords from the articles can provide insights into the development and evolution of sustainable furniture design research themes.

Drawing upon the aforementioned examination, we employed VOSviewer to construct a cluster map of keywords, aiming to investigate the general distribution of keyword categories. Each circle on the figure denotes a keyword, with the size of the circle corresponding to the frequency of the keyword's occurrence. The connecting lines between the circles indicate that two keywords have appeared in one or more papers. As illustrated in Figure 8, nine clusters of keywords interact with and relate to each other, including clusters focused on topics such as furniture, mechanical properties, manufacturing, recycling, and behavior; clusters focused on topics such as ergonomics, adolescents, and student seats; clusters focused on topics such as health, consumers, and built environments; and clusters focused on topics such as performance, sustainability, big data, urban furniture, and public space. In Table 6, we present the years in which the top 25 keywords appeared and their termination times. It is evident that before 2014, keywords were predominantly centered on the correlation between furniture and the human body, as well as the experimental investigation of furniture structure and performance, such as school furniture, musculoskeletal disorders, numerical analysis, round mortise, cushion, intervention, etc. From 2015 to 2020, the research direction gradually shifted from the ontology of furniture and the human body to external scope levels, emphasizing the relationship between furniture and life, environment, and the future, with keywords such as temperature, environment, industry, quality of life, green, prediction, etc. In recent years, the research keywords have focused on trends such as the industry chain of furniture, artificial intelligence, and innovative development, with keywords such as deep learning, supply chain, innovation, mechanical property, and challenges.

Table 6. Top 25 Keywords with the Strongest Citation Bursts.

Keywords	Strength	Begin	End	2010–2023
school furniture	3.04	2010	2012	
posture	2.38	2010	2014	
systems	2.95	2011	2012	
randomized controlled trial	2.35	2012	2013	
musculoskeletal disorders	3.18	2013	2014	
numerical analysis	2.92	2013	2014	
care	2.37	2013	2014	
cushion	2.34	2013	2014	
intervention	2.34	2013	2014	
round mortise	2.34	2013	2014	
model	2.71	2014	2015	
simulation	2.7	2014	2016	
prediction	2.96	2015	2016	
temperature	2.54	2015	2018	
environment	4.84	2016	2020	
framework	3.45	2016	2018	
industry	2.35	2016	2019	
quality of life	2.79	2017	2018	
furniture joints	2.91	2018	2020	
green	2.43	2019	2020	
deep learning	3.14	2020	2021	
supply chain	3.06	2020	2023	
innovation	2.71	2020	2023	
mechanical property	3.59	2021	2023	
challenges	2.68	2021	2023	

As depicted in Figure 9, we employed Bibliometrix in R to generate the keyword frequency analysis, the present study has revealed the top five keywords with the highest frequency, namely "design", "performance", "furniture", "size", and "children", accounting for 15%, 5%, 5%, 4%, and 4%, respectively. This finding was further complemented by other keywords such as "model", "strength", "behavior", and "classroom furniture", each accounting for 3%, and a few others such as "health", "management", "wood", and "school furniture" each accounting for 2%. Additionally, certain keywords such as "physical activity", "building", "temperature", "environment", "prediction", and "risk factors" each have a frequency of 1%. The research findings suggest that the main research focus is centered on the design and functional characteristics of furniture, the dimensions of the human body, green health sustainability, environmental and adaptability factors, with special emphasis on children and classroom furniture.

In this study, we investigated the primary keywords in research fields across various countries. Figure 10 provides insights into the top 20 countries and their respective top 20 research theme keywords. The length of the left color block represents the number of keywords used in different countries, while the length of the right color block indicates the total number of keywords. The data analysis revealed that China has the highest number of involved keywords (19), followed by the United States (16) and Brazil (16). Our findings suggest that the research keywords in different countries primarily focus on the study of furniture's own performance attributes, such as "mechanical properties", "wood", "impact", and "composite materials". In addition, the research also concentrates on the

external functions and green development of furniture, such as "behavior", "design", and "formaldehyde".

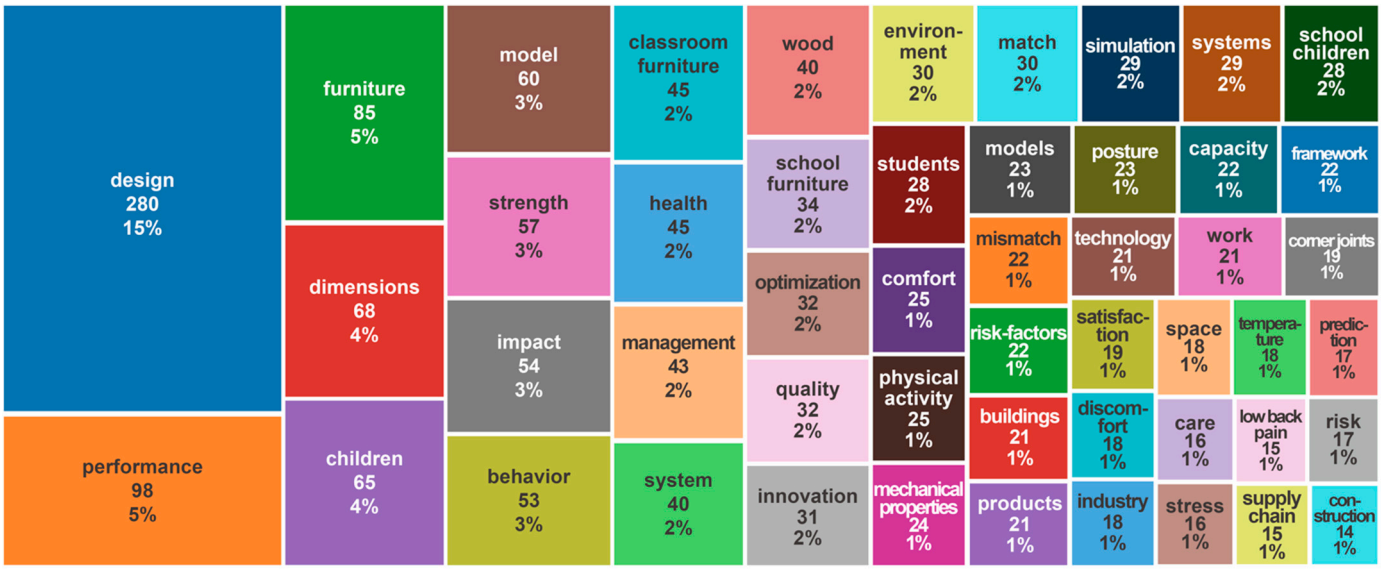


Figure 9. Word count frequency of keywords.

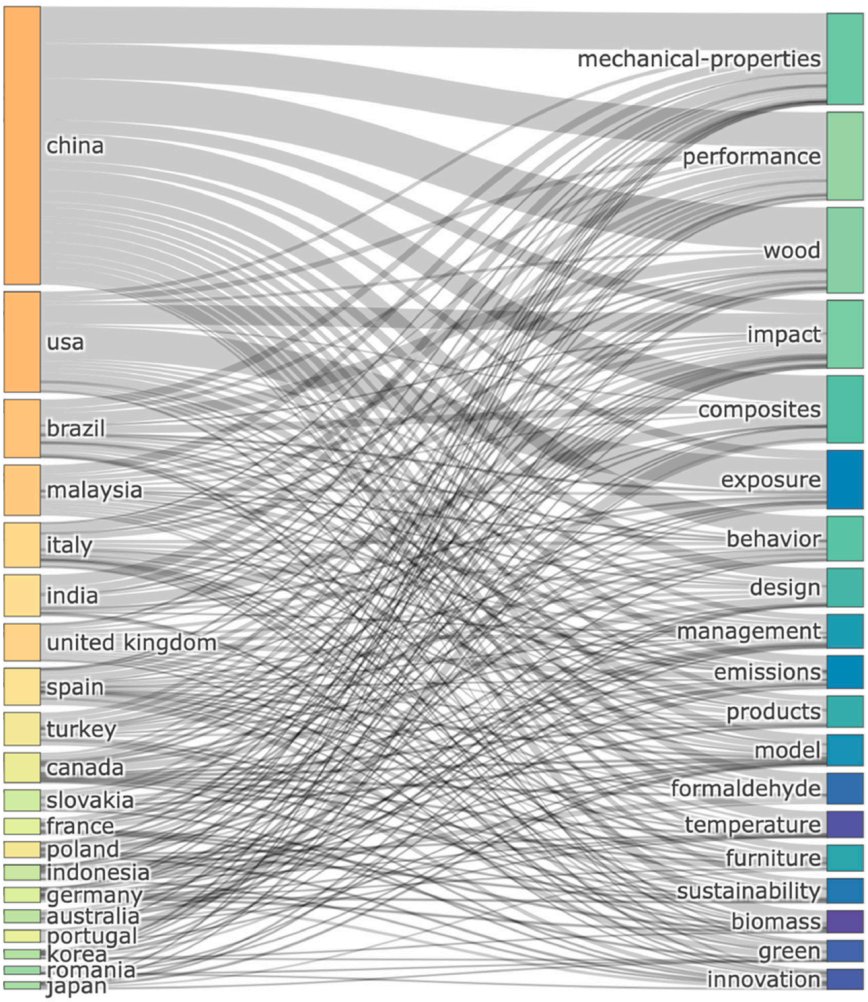


Figure 10. Research keywords of the top 20 ranked countries.

5. Discussion

5.1. Extent of Available Research Literature

Based on the bibliometric analysis, sustainable furniture design has become an increasingly popular research field, particularly since 2016, with active participation from several countries in Asia, the Americas, and Oceania. In the current global climate, sustainable furniture design has become a subject of particular interest due to its relationship to sustainable development. China and the United States have emerged as key collaborators in this field, with China being the leading furniture producer, consumer, and exporter, and the United States being its largest export market [4]. In addition to its vast population, China's scientific research landscape is characterized by a formidable workforce, as of 2021. The country's population stands at roughly 1.4 billion, and the 2021 China Science and Technology Statistical Report reveals that over five million scientific research personnel are currently employed in China. This figure encompasses full-time and part-time researchers, postdoctoral fellows, teachers, students, and others, with the majority working in academic research across universities, research institutions, and laboratories. This extensive scientific research workforce provides insight into the breadth and scope of China's collaborations and research initiatives with other countries. However, the level of cooperation between countries in this area is relatively low, emphasizing the need for increased international collaboration to advance research in this field.

In accordance with the analysis of academic publications, influential authors, and significant institutions, the field of research has a multifaceted focus on topics such as structural performance, manufacturing technology, material research, environmental science, and ecology, which presents a diverse research landscape. While this diversity provides opportunities for broader research practices and topics, we contend that research at this stage must be carried out through a gradual process of refining the focus. It is important to note that, although China dominates in terms of publication output and is a key contributor to institutional collaboration, its article citation rate is not the highest. The research conducted by Sydor et al. [9] aligns with the present study, in which 1465 scientific publications and 2,880,188 patent documents were examined. Despite the dominance of Chinese and American authors in terms of scientific output, the results indicated that American authors received the highest number of citations. Suggesting that the research findings from Chinese researchers have yet to gain significant influence. Therefore, further consideration must be given to the direction, quality, and efficacy of the research presented in these articles.

5.2. Current Critical Topics in Research Literature

According to the results of the co-citation analysis, this study has identified six main research themes in the sustainable furniture design field. These themes are related to the accuracy of furniture that matches the human body scale, the performance and function of furniture joints and other structures, the life cycle of furniture and its carbon emissions analysis, school furniture, safety, and quality design of furniture, and furniture strength and load. These research topics are both short-term and long-term and highlight the importance of refining a single element to improve the sustainability of furniture design. The evaluation of these research topics reveals that sustainable furniture design encompasses not only the functional characteristics of furniture but also the systemic impact of the external environment. However, the small-scale limitations of these active topics highlight the need for further research to expand the scope of the field.

Based on the analysis of research keywords, it has been observed that recent emerging topics are moving towards comprehensive research on a larger scale that encompasses multiple elements and fields. The present research trends encompass the furniture industry chain, artificial intelligence, and innovative development. Although the materials, structures, and performance of furniture are deemed essential components of sustainable development, factors such as health, environment, risk, and prediction also hold significant importance in research. The study by Maresova et al. [79] highlights the potential of intelli-

gent information and communication technology (ICT) solutions for addressing emerging trends and possibilities in the areas of smart environment and health issues. The authors underscore the need for innovative ICT solutions to facilitate sustainable development and promote the well-being of individuals and communities. Currently, emerging topics integrate the characteristics of short-term and long-term research, and multidisciplinary research has become a prevalent trend and direction.

5.3. Future Research Trend Prediction

After analyzing, reviewing, and summarizing our research results, we have identified three main themes for future research in sustainable furniture design, which are multidimensional connections, health and intelligence, and environment and systems, as depicted in Figure 11. Each trend theme encompasses long-term active, short-term active, and emerging research topics, indicating the systematic and sustained advancement of the themes.

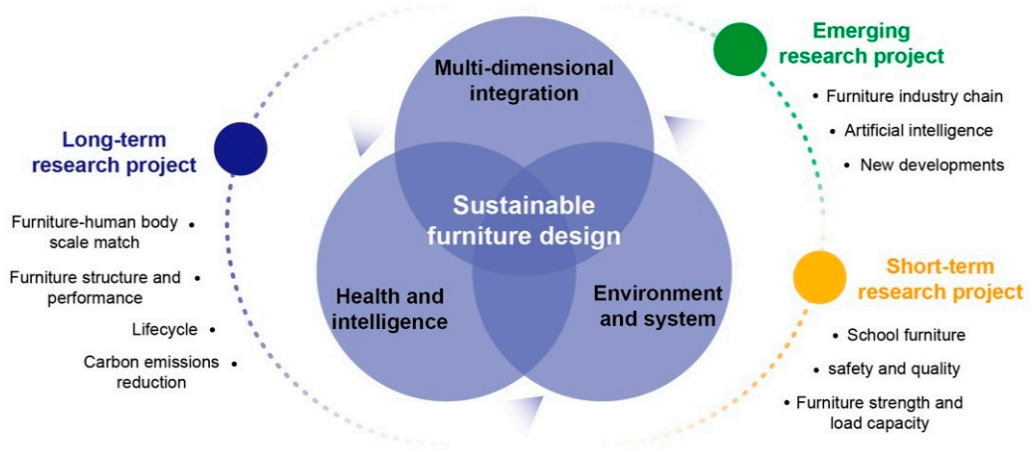


Figure 11. Three themes of sustainable furniture design.

5.3.1. Theme 1: Multi-Dimensional Integration

This theme emphasizes the multidimensional integration of research topics and methods in sustainable furniture design. Currently, most literature assesses the factors influencing a single furniture characteristic, such as structure, material performance, or human–machine interaction. Wu [31] introduced the "reduction principle" from green design in modern furniture mortise and tenon structural design, exploring new ideas and methods for modern mortise and tenon structural design. Kyung [80] studied the effects of wood and surface treatment methods on harmful substance content in wooden furniture. Zhu [81] analyzed the application status of green materials in domestic and foreign office furniture companies, and proposed strategies for selecting environmentally friendly materials for major materials and packaging materials for office furniture. Cheng [82] analyzed the main ergonomic impacts on seat function and usability. However, the material performance of furniture affects structural design, which in turn affects function and human-machine interaction. In their study, Sydor et al. [10] conducted a comprehensive review of 92 scientific publications and 212 patent documents to demonstrate the multifaceted benefits of ecological biomaterials in interior design. The findings suggest that these materials offer not only high aesthetic value but also promote more uniform internal structures. As a result, ecological biomaterials have garnered increased attention from interior designers seeking to create sustainable and visually appealing spaces. These insights contribute to the ongoing discourse on sustainable design practices and underscore the importance of incorporating ecologically friendly materials in interior design. In summary, each performance element exists as a whole with mutual influence, and the development of sustainable furniture design systems will be the focus of future research.

Regarding research methods, Wei [83] combined fuzzy technology with structured design technology, focusing on the use of environmentally friendly materials in furniture design, and constructed a fuzzy technology-based children's furniture design system. Vermeer [84] used machine learning to design novel furniture. Li [85] used the evaluation grid method in Miryoku engineering to guide straw furniture design research and practice. Matwiej [86] used the finite element method and empirical research to design the framework of soft cushion furniture and developed a 3D discrete model of the soft cushion furniture frame. The emphasis and adaptability of different research methods for research topics are different and have their own limitations. For the systematic research of sustainable furniture design, the application of methods will no longer be singular, and it is necessary to explore the fusion of different methods for application, which should be strengthened in subsequent research.

5.3.2. Theme 2: Health and Intelligence

The health issues related to furniture have received attention during the COVID-19 pandemic, and healthy furniture design can be seen as a concept of a new lifestyle. These studies involve the impact of furniture function and style on the human skeletal and muscular systems, the effect of furniture materials on the human body and space, and consider the dimensions of human body measurements for safety, health, and well-being, including ergonomic standards, social psychology aspects, and post-pandemic policies [87,88]. Monitoring furniture purchase behavior has revealed a high proportion of positive preferences for quality and design, with greater emphasis on health factors, which is important for insights into future furniture design [89]. This is particularly evident in urban furniture, including reducing contact, effective disinfection, good appearance, social and cultural symbols, ergonomic design, intelligent systems and technology, and sustainability, to meet availability, hygiene, and health and emotional well-being [90]. The World Health Organization defines health as a state of physical and mental well-being with the ability to adapt, rather than simply being free from illness and weakness. This research trend not only focuses on explicit safety and health issues, but also addresses potential sub-health problems, aiming to provide a healthy and sustainable living environment and promote well-being in terms of both psychological and physical health, such as reducing work pressure and achieving design for the purpose of health preservation.

Intelligence in sustainable furniture design not only manifests in the functional usage on the user end, but also in the furniture manufacturing end, creating an integrated system of smart manufacturing, usage, and services. Smart furniture is equipped with intelligent systems or uses user data and energy-operated controllers to communicate and predict user needs through multiple sensors and actuators in the user environment, resulting in furniture that adapts to users' needs [91]. Research on user pain points, intelligent technology, and economic potential will be the next focus to improve user well-being and quality of life [92]. In the intelligent processing and production of furniture, technologies such as big data, digital twins, and machine vision can be used for information collection, quality inspection, positioning, automatic sorting, and intelligent monitoring, which can increase production efficiency and reduce labor time [93]. The study conducted by Wang et al. [94] sheds light on the crucial role of smart manufacturing technology in enhancing the quality control of furniture products. The findings highlight the potential of this technology to significantly improve the overall sustainability and efficiency of the furniture production process. This study adds to the growing body of research on sustainable manufacturing practices and underscores the importance of integrating cutting-edge technologies in the pursuit of sustainable furniture production. Based on this, it is necessary to study the intelligent furniture design framework, which is extremely helpful in collecting a large amount of demand information, manufacturing capacity, and market trends data to enhance product design market performance, design performance, and sustainability [95].

5.3.3. Theme 3: Environment and System

Although the importance of furniture has been established, its overall relationship with life and space is often neglected, such as in urban spaces and architectural spaces. The functional performance of the furniture is reflected in serving human activities such as rest, work, and leisure. Essentially, the furniture industry and market, as well as its interaction with humans and symbiotic relationship with the environment, determine its sustainable existence. With the focus on research topics and keywords in recent years, the concept of sustainable furniture design has gradually expanded to the study of spatial environments and supply chains. Increasingly, more literature is devoted to sustainable furniture in the environment and its supply chain system.

Regarding the sustainable design research of furniture in spatial environments, Lin [96] advocates for the importance of furniture's environmental performance on the environment and health, laying a theoretical foundation for new thinking in furniture design based on ecological needs. Suandi [7] proposed principles in which manufacturers and customers' needs for environmental characteristics, economic characteristics, and social sustainability characteristics are taken into account during the furniture design process, which is of significant importance for achieving standardization. Alpak [97] discusses the requirements for functional, aesthetic, and creative abilities in furniture design in landscape architecture environments. Dazkir [98] studied the influence of furniture forms on emotional reactions in indoor environments, expanding empirical findings on furniture emotions and forms. As Japanese famous architect Yoshinobu Ashihara said, space is essentially formed by the relationship between an object and the person who perceives it, and people are also sensitive to the design language of emotions or care. The social effects of urban furniture and its human-centered cultural attributes make it an important medium for interpersonal communication and emotional exchange in life [99]. The study of human use and emotional needs, furniture functionality and styling, and spatial environments are inseparable. Sustainable furniture design needs to consider the overall environmental system and users' demands.

In terms of the supply chain in the furniture industry, the abilities and professional training of furniture designers have been given attention [100]. In the driving factors and challenges of the furniture industry, external inputs, market demand, and internal research and development are the most important drivers of furniture design innovation, which must be transformed and advanced through innovation and value-added to the value chain [101]. In addition, green supply chain management, ecological and environmental labels, and related market communication are key to sustainable practices in furniture design and enhancing a company's competitiveness [6]. The concept of upcycling furniture waste to create new or updated products and reintroducing them into circulation is a viable and sustainable design strategy that can generate positive outcomes for environmental and socio-economic advancement throughout the supply chain and market distribution. Repurposing abandoned furniture materials can facilitate creativity and originality, enabling designers to fabricate one-of-a-kind, sustainable, and pioneering merchandise such as particleboard or fiberboard furniture that fulfills customers' desires for eco-friendliness and customization [70]. This methodology can aid firms in diminishing expenses, augmenting productivity, and curbing their reliance on resources. So, in the lifecycle of furniture design, manufacturing, and sales services, market-oriented research, sustainable production, consumption, and marketing are the abilities to maintain competitive advantages and improve efficiency. As an important premise for the sustainable development of furniture, the systematic research of the industry supply chain should be further widely studied.

5.4. Limitations

The study has several limitations that need to be acknowledged. Firstly, only data from the WOS database was used in this study, and future studies could incorporate other databases, such as Scopus, to broaden the scope of the bibliometric review. Secondly, while a comprehensive search strategy was employed and the initial data set was manually

screened, the multi-disciplinary nature of sustainable furniture design means that some relevant papers may have been missed. However, by utilizing various search strategies and techniques, the authors were able to generate robust data and minimize the risk of errors in the analysis. Finally, it is important to recognize the inherent limitations of bibliometric analysis, such as the fact that more recent publications may have an advantage in terms of citations, and that papers with lower citation rates may still contain valuable insights that require further examination. Despite these limitations, the combination of quantitative and qualitative analysis in this study provides a valuable perspective on sustainable furniture design research over the past two decades, and offers important insights for future researchers in this field.

6. Conclusions

6.1. More Detailed Information about the Methodology Used

In this review, a bibliometric analysis of 1578 papers on sustainable furniture design was conducted using scientific mapping techniques such as collaboration, co-citation, and keyword co-occurrence analysis. Utilizing three widely adopted tools, namely, BibliometrixR package (stable version), VOSviewer (version 1.6.19), and CiteSpace (version 5.8.R3), the present study conducted a comprehensive bibliometric analysis on various aspects of scholarly outputs, including yearly publications, scholarly journals, authors and institutions, references, and keywords. The outcomes of this analysis were then thoroughly examined and discussed with the aid of the aforementioned bibliometric software systems.

6.2. Results

The study identified several significant findings. Firstly, sustainable furniture design has been receiving increasing attention, and the annual publication rate has generally increased in recent years. Secondly, nations involved in investigating this field encompass a diverse range of regions, including Asia, the Americas, Europe, and Oceania, with a strong collaboration between China and the United States. Thirdly, journal sources, influential authors, and institutions that contribute to sustainable furniture design are closely related to product technology science, environmental science, ecology, and material research, highlighting the multidisciplinary nature of research in this field. Fourthly, highly cited papers focus on furniture efficacy and development, material and structural performance, marketing and supply chain systems, and school furniture. Fifthly, co-cited papers identified three long-term research topics and three short-term research topics, including Cluster #0 focusing on Accuracy precision, Cluster #1 on And-tenon joint, Cluster #3 on Wooden furniture and Cluster #2 High school student, Cluster #4 Security quality, Cluster #5 Analysis.

6.3. "Current Key Research Themes" and "Potential Future Directions"

The emerging research topics and the main topics of interest were analyzed through keyword clustering and word frequency analysis across different time periods. Prior to 2014, research in the field of furniture primarily focused on "school furniture", "musculoskeletal disorders", and "numerical analysis", with a specific interest in investigating the relationship between furniture and the human body through experimental analysis of furniture structure and performance. Between 2015 and 2020, research interest shifted to keywords such as "temperature", "environment", and "industry", where the focus was on exploring the link between furniture and the broader themes of life, environment, and future sustainability. In recent years, research in the field has evolved to incorporate themes such as "deep learning", "supply chain", and other areas, indicating a trend toward investigating innovative furniture development, artificial intelligence, and the industrial chain. Moreover, research keywords of interest include furniture design, functional characteristics, human body scale, green health, and sustainability, environmental and adaptability factors, with a higher proportion of studies targeting chil-

dren and classroom furniture. International research efforts have primarily concentrated on studying the intrinsic performance of furniture, investigating topics such as "mechanical properties", "wood", "impact", and "composite materials", with a growing interest in exploring external functions and green development such as "behavior", "design", and "formaldehyde".

Finally, based on the bibliometric analysis results, the research trends of sustainable furniture design were discussed in terms of multidimensional integration, health and intelligence, and environment and systems. In sustainability research, each emerging trend topic encompasses a variety of long-term active, short-term active, and emerging research subtopics, thereby shedding light on the systematic and continuous nature of theme development. This study aims to provide valuable references for researchers in the field of sustainable furniture design.

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References

1. Analysis and Forecast of the Global Furniture Market Size and Development Trends in 2022. Available online: https://baijiahao.baidu.com/s?id=1721175409602665967&wfr=spider&for=pc (accessed on 1 June 2022).
2. Silvius, G.; Ismayilova, A.; Sales-Vivo, V.; Costi, M. Exploring Barriers for Circularity in the EU Furniture Industry. *Sustainability* **2021**, *13*, 11072. [CrossRef]
3. Keitsch, M. Sustainable Design: A Brief Appraisal of its Main Concepts. *Sustain. Dev.* **2012**, *20*, 180–188. [CrossRef]
4. Lin, M. The Conflict between Technology and Scale: Evidence from China's Wooden Furniture Industry. *Sustainability* **2023**, *15*, 230. [CrossRef]
5. Ribeiro Massote, C.H.; Moura Santi, A.M. Implementation of a cleaner production program in a Brazilian wooden furniture factory. *J. Clean. Prod.* **2013**, *46*, 89–97. [CrossRef]
6. Bumgardner, M.S.; Nicholls, D.L. Sustainable Practices in Furniture Design: A Literature Study on Customization, Biomimicry, Competitiveness, and Product Communication. *Forests* **2020**, *11*, 1277. [CrossRef]
7. Suandi, M.E.M.; Amlus, M.H.; Hemdi, A.R.; Abd Rahim, S.Z.; Ghazali, M.F.; Rahim, N.L. A Review on Sustainability Characteristics Development for Wooden Furniture Design. *Sustainability* **2022**, *14*, 8748. [CrossRef]
8. Grzegorzewska, E.; Wieckowska, M. Market threats and opportunities in the implementation of sustainable products–Results from empirical study of furniture industry. *Drewno* **2017**, *60*, 111–123. [CrossRef]
9. Sydor, M.; Kwapich, A.; Lira, J.; Langova, N. Bibliometric study of the cooperation in the engineering and scientific publications related to furniture design. *Drewno* **2022**, *65*, 52–67. [CrossRef]
10. Sydor, M.; Bonenberg, A.; Doczekalska, B.; Cofta, G. Mycelium-Based Composites in Art, Architecture, and Interior Design: A Review. *Polymers* **2022**, *14*, 145. [CrossRef]
11. Liu, J.; Liu, Z.; Yang, Q.; Osmani, M.; Demian, P. A Conceptual Blockchain Enhanced Information Model of Product Service Systems Framework for Sustainable Furniture. *Buildings* **2023**, *13*, 85. [CrossRef]
12. Jia, G.-L.; Ma, R.-G.; Hu, Z.-H. Review of Urban Transportation Network Design Problems Based on CiteSpace. *Math. Probl. Eng.* **2019**, *2019*, 5735702. [CrossRef]
13. Bonilla-Chaves, E.F.; Palos-Sánchez, P.R. Exploring the Evolution of Human Resource Analytics: A Bibliometric Study. *Behav. Sci.* **2023**, *13*, 244. [CrossRef] [PubMed]
14. Suhaily, S.S.; Jawaid, M.; Abdul Khalil, H.P.S.; Mohamed, A.R.; Ibrahim, F. A review of oil palm biocomposites for furniture design and applications: Potential and challenges. *Bioresources* **2012**, *7*, 4400–4423.

15. Wang, Y.; Liu, C.; Zhang, X.; Zeng, S. Research on Sustainable Furniture Design Based on Waste Textiles Recycling. *Sustainability* **2023**, *15*, 3601. [CrossRef]
16. Xiong, X.; Ma, Q.; Yuan, Y.; Wu, Z.; Zhang, M. Current situation and key manufacturing considerations of green furniture in China: A review. *J. Clean. Prod.* **2020**, *267*, 121957. [CrossRef]
17. Cobo, M.J.; Lopez-Herrera, A.G.; Herrera-Viedma, E.; Herrera, F. Science Mapping Software Tools: Review, Analysis, and Cooperative Study Among Tools. *J. Am. Soc. Inf. Sci. Technol.* **2011**, *62*, 1382–1402. [CrossRef]
18. Walsh, I.; Rowe, F. BIBGT: Combining bibliometrics and grounded theory to conduct a literature review. *Eur. J. Inf. Syst.* 2022, *in press*. [CrossRef]
19. Shen, Z.; Ji, W.; Yu, S.; Yuan, Q.; Yang, T.; Cheng, G.; Han, Z.; Liu, H. Mapping the knowledge of traffic collision Reconstruction: A scientometric analysis in CiteSpace, VOSviewer, and SciMAT. *Sci. Justice* **2023**, *63*, 19–37. [CrossRef]
20. Smardzewski, J.; Klos, R.; Fabisiak, B. Determination of the impact of creeping of furniture joints on their rigidity. *Turk. J. Agric. For.* **2013**, *37*, 802–811. [CrossRef]
21. Smardzewski, J.; Lewandowski, W.; Imirzi, H.O. Elasticity modulus of cabinet furniture joints. *Mater. Des.* **2014**, *60*, 260–266. [CrossRef]
22. Castellucci, H.I.; Arezes, P.M.; Molenbroek, J.F.M. Equations for defining the mismatch between students and school furniture: A systematic review. *Int. J. Ind. Ergon.* **2015**, *48*, 117–126. [CrossRef]
23. Ratnasingam, J.; Ab Latib, H.; Yi, L.Y.; Liat, L.C.; Khoo, A. Extent of Automation and the Readiness for Industry 4.0 among Malaysian Furniture Manufacturers. *Bioresources* **2019**, *14*, 7095–7110. [CrossRef]
24. Tankut, N.; Tankut, A.N.; Zor, M. Finite Element Analysis of Wood Materials. *Drv. Ind.* **2014**, *65*, 159–171. [CrossRef]
25. Zhang, H.; Shen, H. Study of Pattern Recognition of Morphological Characters for Furniture Image Cognition. In Proceedings of the 5th International Conference on Intelligent Systems Design and Engineering Applications (ISDEA), Hunan, China, 15–16 June 2014; pp. 926–930.
26. Kasal, A.; Eckelman, C.A.; Haviarova, E.; Erdil, Y.Z.; Yalcin, I. Bending Moment Capacities of L-Shaped Mortise and Tenon Joints under Compression and Tension Loadings. *Bioresources* **2015**, *10*, 7009–7020. [CrossRef]
27. Erdil, Y.Z.; Haviarova, E.; Eckelman, C.A. Product engineering and performance testing in relation to strength design of furniture. *Wood Fiber Sci.* **2004**, *36*, 411–416.
28. Hakansson, K.M.O.; Henriksson, I.C.; de la Peña Vazquez, C.; Kuzmenko, V.; Markstedt, K.; Enoksson, P.; Gatenholm, P. Solidification of 3D Printed Nanofibril Hydrogels into Functional 3D Cellulose Structures. *Adv. Mater. Technol.* **2016**, *1*, 1600096. [CrossRef]
29. Xu, X.; Wang, S.; Yu, Y. Consumer's intention to purchase green furniture: Do health consciousness and environmental awareness matter? *Sci. Total Environ.* **2020**, *704*, 135275. [CrossRef]
30. Xu, W.; Wu, Z.; Zhang, J. Compressive creep and recovery behaviors of seat cushions in upholstered furniture. *Wood Fiber Sci.* **2015**, *47*, 431–444.
31. Wu, W.; Zhu, J.g.; Xu, W.; Han, F.; Wu, X.; Wang, X. Innovative Design of Modern Mortise and Tenon Structure under the Concept of Green Reduction. *Bioresources* **2021**, *16*, 8445–8456. [CrossRef]
32. Qi, Y.; Shen, L.; Zhang, J.; Yao, J.; Lu, R.; Miyakoshi, T. Species and release characteristics of VOCs in furniture coating process. *Environ. Pollut.* **2019**, *245*, 810–819. [CrossRef]
33. Zheng, Y.; Zhu, J. The Application of Bamboo Weaving in Modern Furniture. *Bioresources* **2021**, *16*, 5024–5035. [CrossRef]
34. Wu, X.; Zhu, J.; Wang, X. A Review on Carbon Reduction Analysis during the Design and Manufacture of Solid Wood Furniture. *Bioresources* **2021**, *16*, 6212–6230. [CrossRef]
35. Xiong, X.; Wu, Z.-H. The framework of information collection and data management for mass customization furniture. *AMR* **2011**, *317–319*, 88–92. [CrossRef]
36. Lin, L.; Su, Z.; Zhang, H.; Zhou, G.; Zhou, H.; Ren, J.; Wang, X.; Liu, C.; Wang, X. Thermo-processable chitosan-based plastic substitute with self-adaptiveness and closed-loop recyclability. *Carbohydr. Polym.* **2022**, *291*, 119479. [CrossRef] [PubMed]
37. Li, S.; Chen, M.; Lyu, J. User-based Furniture Recycling System Innovation and Its Implementation. In Proceedings of the 5th International Conference on Sustainable Energy and Environment Engineering (ICSEEE), Zhuhai, China, 12–13 November 2016; pp. 830–836.
38. Chen, M.; Jiang, L.; Liu, D.-Z.; Lyu, J.-h. Furniture Innovative Design with Earthquake Self-Rescue Function: From Furniture Form and Structure Perspective. In Proceedings of the 2nd International Conference on Informatization in Education, Management and Business (IEMB), Guangzhou, China, 12–13 September 2015; pp. 35–40.
39. Chen, M.; Liu, D.-Z.; Jiang, L.; Lyu, J.-h. Primary Research on Emergency Self-Rescue Furniture Design for Natural Disasters. In Proceedings of the 2nd International Conference on Informatization in Education, Management and Business (IEMB), Guangzhou, China, 12–13 September 2015; pp. 943–949.
40. Feng, K.; Chen, M.; Lyu, J. Research on Innovative Design of Bathroom Furniture Based on Olfactory Experience. In Proceedings of the 2nd International Conference on Computer Engineering, Information Science and Application Technology (ICCIA), Wuhan, China, 8–9 July 2017; pp. 497–502.
41. Gejdos, M.; Hitka, M. The Impact of the Secular Trend of the Slovak Population on the Production of Wooden Beds and Seating Furniture. *Forests* **2022**, *13*, 1599. [CrossRef]

42. Marcinekova, K.; Sujova, A. Business Model for The Process Evaluation. In Proceedings of the 10th Annual International Scientific Conference on More Wood, Better Management, Increasing Effectiveness: Setting Points and Perspectives, Prague, Czech Republic, 24–26 May 2017; pp. 52–57.
43. Olsiakova, M.; Loucanova, E.; Kalamarova, M. Application of New Trends of Marketing Communication as a Competitiveness Tool in Furniture Industry. In Proceedings of the 10th Annual International Scientific Conference on More Wood, Better Management, Increasing Effectiveness: Setting Points and Perspectives, Prague, Czech Republic, 24–26 May 2017; pp. 5–10.
44. Mat'ova, H.; Triznova, M.; Dzian, M. Different Profiles of Brand Personality–The Result of Two Independent Measurements. In Proceedings of the International Conference on the Path Forward for Wood Products: A Global Perspective, Baton Rouge, LA, USA, 5–8 October 2016; pp. 181–186.
45. Sujova, A.; Hlavackova, P.; Marcinekova, K. The trade competitiveness of furniture products. *Drewno* **2015**, *58*, 101–115. [CrossRef]
46. Siti Suhaily, S.; Islam, M.N.; Asniza, M.; Rizal, S.; Abdul Khalil, H.P.S. Physical, mechanical and morphological properties of laminated bamboo hybrid composite: A potential raw material for furniture manufacturing. *Mater. Res. Express* **2020**, *7*, 075503. [CrossRef]
47. Abdo, F.M.; Ibrahim, F. A Conceptual Review of the Cultural Significance of 'Takhtah Table'. In Proceedings of the International Conference of Global Network for Innovative Technology (IGNITE)/AWAM International Conference on Civil Engineering (AICCE), Penang, Malaysia, 8–9 August 2017.
48. Abdulqader, O.Q.; Ibrahim, F.; Bahauddin, A. The Algorithm Processes of Generating Embellishments in the Baba-Nyonya Shophouses. In Proceedings of the International Conference on Architecture and Built Environment (ICABE), Kuala Lumpur, Malaysia, 7 July 2017; pp. 6218–6222.
49. Stapleton, H.M.; Klosterhaus, S.; Eagle, S.; Fuh, J.; Meeker, J.D.; Blum, A.; Webster, T.F. Detection of Organophosphate Flame Retardants in Furniture Foam and US House Dust. *Environ. Sci. Technol.* **2009**, *43*, 7490–7495. [CrossRef]
50. Gemser, G.; Leenders, M. How integrating industrial design in the product development process impacts on company performance. *J. Prod. Innov. Manag.* **2001**, *18*, 28–38. [CrossRef]
51. Merrell, P.; Schkufza, E.; Li, Z.; Agrawala, M.; Koltun, V. Interactive Furniture Layout Using Interior Design Guidelines. *Acm Trans. Graph.* **2011**, *30*, 87. [CrossRef]
52. Dangelico, R.M.; Pontrandolfo, P.; Pujari, D. Developing Sustainable New Products in the Textile and Upholstered Furniture Industries: Role of External Integrative Capabilities. *J. Prod. Innov. Manag.* **2013**, *30*, 642–658. [CrossRef]
53. Gouvali, M.K.; Boudolos, K. Match between school furniture dimensions and children's anthropometry. *Appl. Ergon.* **2006**, *37*, 765–773. [CrossRef] [PubMed]
54. Navas-Aleman, L. The Impact of Operating in Multiple Value Chains for Upgrading: The Case of the Brazilian Furniture and Footwear Industries. *World Dev.* **2011**, *39*, 1386–1397. [CrossRef]
55. Amick, B.C.; Robertson, M.M.; DeRango, K.; Bazzani, L.; Moore, A.; Rooney, T.; Harrist, R. Effect of office ergonomics intervention on reducing musculoskeletal symptoms. *Spine* **2003**, *28*, 2706–2711. [CrossRef] [PubMed]
56. Stapleton, H.M.; Sharma, S.; Getzinger, G.; Ferguson, P.L.; Gabriel, M.; Webster, T.F.; Blum, A. Novel and High Volume Use Flame Retardants in US Couches Reflective of the 2005 PentaBDE Phase out. *Environ. Sci. Technol.* **2012**, *46*, 13432–13439. [CrossRef]
57. Zota, A.R.; Rudel, R.A.; Morello-Frosch, R.A.; Brody, J.G. Elevated House Dust and Serum Concentrations of PBDEs in California: Unintended Consequences of Furniture Flammability Standards? *Epidemiology* **2008**, *19*, S161.
58. Jou, M. Real time monitoring weld quality of resistance spot welding for the fabrication of sheet metal assemblies. *J. Mater. Process. Technol.* **2003**, *132*, 102–113. [CrossRef]
59. Yu, Y.; Wang, X.; Zhong, R.Y.; Huang, G.Q. E-commerce logistics in supply chain management Implementations and future perspective in furniture industry. *Ind. Manag. Data Syst.* **2017**, *117*, 2263–2286. [CrossRef]
60. De Medeiros, J.F.; Duarte Ribeiro, J.L.; Cortimiglia, M.N. Influence of perceived value on purchasing decisions of green products in Brazil. *J. Clean. Prod.* **2016**, *110*, 158–169. [CrossRef]
61. Panagiotopoulou, G.; Christoulas, K.; Papanckolaou, A.; Mandroukas, K. Classroom furniture dimensions and anthropometric measures in primary school. *Appl. Ergon.* **2004**, *35*, 121–128. [CrossRef]
62. Dianat, I.; Molenbroek, J.; Ignacio Castellucci, H. A review of the methodology and applications of anthropometry in ergonomics and product design. *Ergonomics* **2018**, *61*, 1696–1720. [CrossRef] [PubMed]
63. Sanjog, J.; Patel, T.; Karmakar, S. Occupational ergonomics research and applied contextual design implementation for an industrial shop-floor workstation. *Int. J. Ind. Ergon.* **2019**, *72*, 188–198. [CrossRef]
64. Dawal, S.Z.M.; Ismail, Z.; Yusuf, K.; Abdul-Rashid, S.H.; Shalahim, N.S.M.; Abdullah, N.S.; Kamil, N.S.M. Determination of the significant anthropometry dimensions for user-friendly designs of domestic furniture and appliances–Experience from a study in Malaysia. *Measurement* **2015**, *59*, 205–215. [CrossRef]
65. Hu, W.G.; Wan, H.; Guan, H.Y. Study on Contact Force Relaxation Behavior of Mortise-and-Tenon Joints Considering Tenon Fits and Grain Orientations of Tenon. *Bioresources* **2018**, *13*, 5608–5616. [CrossRef]
66. Kasal, A.; Smardzewski, J.; Kuskun, T.; Erdil, Y.Z. Numerical Analyses of Various Sizes of Mortise and Tenon Furniture Joints. *Bioresources* **2016**, *11*, 6836–6853. [CrossRef]
67. Imirzi, H.O.; Smardzewski, J.; Dongel, N. Method for substitute modulus determination of furniture frame construction joints. *Turk. J. Agric. For.* **2015**, *39*, 775–785. [CrossRef]

68. Bianco, I.; Thiebat, F.; Carbonaro, C.; Pagliolico, S.; Blengini, G.A.; Comino, E. Life Cycle Assessment (LCA)-based tools for the eco-design of wooden furniture. *J. Clean. Prod.* **2021**, *324*, 129249. [CrossRef]
69. Medeiros, D.L.; Tavares, A.O.D.; Raposo, A.; Kiperstok, A. Life cycle assessment in the furniture industry: The case study of an office cabinet. *Int. J. Life Cycle Assess.* **2017**, *22*, 1823–1836. [CrossRef]
70. Yang, D.R.; Zhu, J. Recycling and Value-added Design of Discarded Wooden Furniture. *Bioresources* **2021**, *16*, 6953–6963. [CrossRef]
71. Tunay, M.; Melemez, K. An analysis of biomechanical and anthropometric parameters on classroom furniture design. *Afr. J. Biotechnol.* **2008**, *7*, 1081–1086.
72. Batistao, M.V.; Sentanin, A.C.; ShinoharaMoriguchi, C.; Hansson, G.A.; Coury, H.; Sato, T.D. Furniture dimensions and postural overload for schoolchildren's head, upper back and upper limbs. *Work A J. Prev. Assess. Rehabil.* **2012**, *41*, 4817–4824. [CrossRef] [PubMed]
73. Zanuncio, S.V.; Mafra, S.C.T.; Antonio, C.E.B.; Lisboa, J.; Guimaraes, E.M.V.; da Silva, V.E.; de Souza, A.P.; Minette, L.J. Determining anthropometric variables as a tool in the preparation of furniture and designs of interior spaces: The case of children 6 to 11 years old of Vicosa, State of Minas Gerais, Brazil. *Work A J. Prev. Assess. Rehabil.* **2012**, *41*, 4626–4632. [CrossRef]
74. Oblak, L.; Jost, M. Methodology for Studying the Ecological Quality of Furniture. *Drv. Ind.* **2011**, *62*, 171–176. [CrossRef]
75. Laurence; Utama, C.P.; Hanafi, J. Statistical Quality Control Measurement on Furniture Manufacturer. In Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore, 6–9 December 2011; pp. 420–423.
76. Berginc, J.; Hrovatin, J.; Feltrin, M.; Machtig, S.; Zupancic, A.; Oblak, L. Analysis of Cooperation Between Furniture Industry and Designers in Product Development Process. *Drv. Ind.* **2011**, *62*, 129–136. [CrossRef]
77. Smardzewski, J.; Klos, R.; Fabisiak, B. Design of small auxetic springs for furniture. *Mater. Des.* **2013**, *51*, 723–728. [CrossRef]
78. Cristiane, A.A.Z.; Danielle, M.D.; Vanessa, C.B. Macroergonomic analysis of an assembly sector of a furniture company. *Work A J. Prev. Assess. Rehabil.* **2012**, *41*, 2768–2775. [CrossRef]
79. Maresova, P.; Krejcar, O.; Barakovic, S.; Husic, J.B.; Lameski, P.; Zdravevski, E.; Chorbev, I.; Trajkovik, V. Health-Related ICT Solutions of Smart Environments for Elderly-Systematic Review. *IEEE Access* **2020**, *8*, 54574–54600. [CrossRef]
80. Kyung, K.J. A Study on the Environment-Friendly Characteristics of Wood Furniture Materials and Finishing Methods for Children. *J. Korea Furnit. Soc.* **2019**, *30*, 402–417.
81. Zhu, J.; Niu, J. Green Material Characteristics Applied to Office Desk Furniture. *Bioresources* **2022**, *17*, 2228–2242. [CrossRef]
82. Cheng, Y.; Tor, O.; Hu, L.; Zheng, W.; Yu, Y. Ergonomics of a Chinese Folk Bamboo Lounge Chair. *Bioresources* **2020**, *15*, 8981–8994. [CrossRef]
83. Wei, P.; Madina, Z. Application of Environmentally Friendly Materials in the Design of Children's Furniture Based on Fuzzy Technology. *Math. Probl. Eng.* **2022**, *2022*, 5165699. [CrossRef]
84. Vermeer, N.; Brown, A.R. Generating Novel Furniture with Machine Learning. In Proceedings of the 11th International Conference on Artificial Intelligence in Music, Sound, Art and Design (EvoMUSART) Held as Part of EvoStar Conference, Madrid, Spain, 20–22 April 2022; pp. 401–416.
85. Li, H.; Wen, K.-H. Research on Design of Stalk Furniture Based on the Concept and Application of Miryoku Engineering Theory. *Sustainability* **2021**, *13*, 13652. [CrossRef]
86. Matwiej, L.; Wieruszewski, M.; Wiaderek, K.; Palubicki, B. Elements of Designing Upholstered Furniture Sandwich Frames Using Finite Element Method. *Materials* **2022**, *15*, 6084. [CrossRef] [PubMed]
87. Incekara, C.O. Post-COVID-19 ergonomic school furniture design under fuzzy logic. *Work A J. Prev. Assess. Rehabil.* **2021**, *69*, 1197–1208. [CrossRef]
88. Incekara, C.O. Designing Ergonomic Post-Covid-19 School Furniture. *S. Afr. J. Ind. Eng.* **2022**, *33*, 37–48. [CrossRef]
89. Barcic, A.P.; Kuzman, M.K.; Vergot, T.; Groselj, P. Monitoring Consumer Purchasing Behavior for Wood Furniture before and during the COVID-19 Pandemic. *Forests* **2021**, *12*, 873. [CrossRef]
90. Liu, J.; Kamarudin, K.M.; Liu, Y.Q.; Zou, J.Z. Developing Pandemic Prevention and Control by ANP-QFD Approach: A Case Study on Urban Furniture Design in China Communities. *Int. J. Environ. Res. Public Health* **2021**, *18*, 2653. [CrossRef]
91. Krejcar, O.; Maresova, P.; Selamat, A.; Melero, F.J.; Barakovic, S.; Husic, J.B.; Herrera-Viedma, E.; Frischer, R.; Kuca, K. Smart Furniture as a Component of a Smart City-Definition Based on Key Technologies Specification. *IEEE Access* **2019**, *7*, 94822–94839. [CrossRef]
92. Zhou, C.M.; Huang, T.; Luo, X.; Kaner, J.; Fu, X.M. Recognition and Analysis of an Age-Friendly Intelligent Sofa Design Based on Skeletal Key-Points. *Int. J. Environ. Res. Public Health* **2022**, *19*, 11522. [CrossRef]
93. Li, R.R.; Zhao, S.C.; Yang, B.K. Research on the Application Status of Machine Vision Technology in Furniture Manufacturing Process. *Appl. Sci.* **2023**, *13*, 2434. [CrossRef]
94. Wang, Q.; Zhan, X.; Wu, Z.; Liu, X.; Feng, X. The Applications of Machine Vision in Raw Material and Production of Wood Products. *Bioresources* **2022**, *17*, 5532–5556. [CrossRef]
95. Tsang, Y.P.; Wu, C.H.; Lin, K.Y.; Tse, Y.K.; Ho, G.T.S.; Lee, C.K.M. Unlocking the power of big data analytics in new product development: An intelligent product design framework in the furniture industry. *J. Manuf. Syst.* **2022**, *62*, 777–791. [CrossRef]
96. Lin, C. The New Thinking on Furniture Design Based on Ecological Demand. *Agro Food Industry Hi-Tech* **2017**, *28*, 450–453.
97. Alpak, E.M.; Duzenli, T.; Mumcu, S. Raising awareness of seating furniture design in landscape architecture education: Physical, activity-use and meaning dimensions. *Int. J. Technol. Des. Educ.* **2020**, *30*, 587–611. [CrossRef]

98. Dazkir, S.S.; Read, M.A. Furniture Forms and Their Influence on Our Emotional Responses Toward Interior Environments. *Environ. Behav.* **2012**, *44*, 722–734. [CrossRef]
99. Yuan, J.; Farnham, C.; Emura, K. Inter-Building Effect and Its Relation with Highly Reflective Envelopes on Building Energy Use: Case Study for Cities of Japan. *Atmosphere* **2017**, *8*, 211. [CrossRef]
100. Fabisiak, B. Characteristics of Design Process Organization in Selected Furniture Manufacturing Companies. *Drv. Ind.* **2016**, *67*, 307–314. [CrossRef]
101. Ratnasingam, J.; Ark, C.K.; Ab Latib, H.; Subramaniam, H.; Khoo, A. Innovation in the Malaysian Furniture Industry: Drivers and Challenges. *Bioresources* **2018**, *13*, 5254–5270. [CrossRef]

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